

Missouri Water Supply Studies

By

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FORWARD

The Missouri Department of Natural Resources, Water Resource Center and Missouri's Safe Drinking Water Program has the responsibility of assisting state residences in assuring an adequate and safe water supply. The purpose of the water supply study is to ensure availability of water information for effective decision-making by communities and MoDNR program managers. In addition, this study is expected to be used to determine and allocate existing water supplies. The scope of this study primarily addresses surface water supplies for cities and communities that are expected to experience water shortages during an extended drought. Surface water supplies consist of lakes, rivers and streams and in many cases combinations of both.

PREFACE

This 2005 Water Supply Report is a result of the State's Water Resources Law water planning mandates and done under the direction of the Missouri Drought Assessment Committee. This report and several previous compact disc versions since 2000 have examined communities at risk and their ability to sustain themselves during drought. Many of these water supplies had only months of water supply assured during recent droughts of 1999-2000 and 2002-2004. Most of the communities are located in the northern and western areas of Missouri. These areas are groundwater poor and dependent upon surface water supplies. Four community supplies that draw most of their water supplies from streams in northern and southern Missouri were also examined for firm yield capability. This study is not a complete evaluation of all communities at risk of depletion of water. Updates to this 2005 Water Supply Report are expected and will be produced by compact disc until the next published edition is planned in 2008.

The authors determined that a hard cover edition was needed to better illustrate to a wider audience the critical water quantity needs of many marginal water supplies in the state.

Contents

	Page
1. Forward.....	ii
2. Preface.....	ii
3. Table of Contents.....	iii
4. Figures.....	v
5. Tables.....	xi
6. Introduction.....	xii
7. Acknowledgments.....	xiv
8. Executive Summary.....	
9. Missouri Water Supply Studies	

Lake Studies

Introduction to Lake Studies.....

1. Adrian	
2. Breckenridge.....	
3. Brookfield.....	
4. Butler.....	
5. Cameron.....	
6. Concordia.....(E.A. Pape Lake).....	
7. Creighton.....	
8. Dearborn.....	
9. Drexel.....	
10. Garden City.....	
11. Green City.....	
12. Hamilton.....	
13. Harrison County Rural Water Dist. #1.....(Eagleville).....	
14. Higginsville.....	
15. Holden.....	
16. James Port.....	
17. King City.....	
18. Lamar.....	
19. Marceline.....	
20. Memphis.....(Lake Show Me).....	
21. Middle Fork Grand River.....(City of Stanberry).....	
22. Milan.....(Elmwood Lake, Golf Course Lake and Lake Shatto).....	
23. Moberly.....	
24. Monroe City RTE "J".....	
25. Ridgeway.....	
26. Sedalia.....	
27. Shelbyna.....	
28. Unionville.....(Lake Mahoney and Lake Thunderhead).....	

Streams and River Analysis

Introduction to Stream and River Studies.....	
40. Joplin: Shoal Creek	
50. Perryville: Saline Creek.....	
60. Poplar Bluff: Black River.....	
70. Trenton: Thompson River.....	

Water Supply Projections

Introduction to water supply projection studies.....

Butler.....

 Harrison County Water District #1 (Eagleville).....

 Hamilton.....

 Marceline.....

 Monroe City Rte “J” Lake.....

9. Appendix A.....

List of Figures

Figure:	Description	Page
<u>1. Adrian</u>		
1.1.a	Storage Volume vs. Elevation (water supply lake).....	
1.1.b	Surface Area vs. Elevation (water supply lake).....	
1.1.c	Storage & Area Curves for small upstream lake.....	
1.2.a	RESOP run results without pumping (normal and optimum).....	
1.2.b	RESOP run results with pumping (normal and optimum).....	
1.2.c	RESOP run results of upper lake.....	
1.3	Historical Water Use.....	
1.4	Lake survey plot.....	
<u>2. Breckenridge</u>		
2.1.a	Storage Volume vs. Elevation (water supply lake).....	
2.1.b	Surface Area vs. Elevation (water supply lake).....	
2.2	RESOP run results (normal and optimum).....	
2.4	Lake survey plot.....	
<u>3. Brookfield</u>		
3.1.a	Storage Volume vs. Elevation (water supply lake).....	
3.1.b	Surface Area vs. Elevation (water supply lake).....	
3.2	RESOP run results (normal and optimum).....	
3.3	Historical Water Use.....	
3.4	Lake survey plot.....	
3.5	Pumping scheme from stream to lake and ponds.....	
<u>4. Butler</u>		
4.1.a	Storage Volume vs. Elevation (water supply lake).....	
4.1.b	Surface Area vs. Elevation (water supply lake).....	
4.2.a	RESOP run results (optimized demand with no pumping).....	
4.2.b	RESOP run results (Normal demand with pumping).....	
4.3	Historical Water Use.....	
4.5	Base Flow Index for Marais Des Cygnes River.....	
4.6	Per cent of flow pumped to Butler Reservoir.....	
<u>5. Cameron</u>		
5.1.a	GLM-A2 Storage Volume vs. Elevation.....	
5.1.b	GLM-A2 Surface Area.....	
5.1.c	City Lake #1 Storage Volume vs. Elevation.....	
5.1.d	City Lake #1 Surface Area vs. Elevation.....	
5.1.e	City Lake #2 Storage Volume vs. Elevation.....	
5.1.f	City Lake #2 Surface Area vs. Elevation.....	
5.1.g	City Lake #3 Storage Volume vs. Elevation.....	
5.1.h	City Lake #3 Surface Area vs. Elevation.....	
5.2.a	RESOP run results (1 MGD pumped to Lake #3).....	
5.2.b	RESOP run results (Lake #3 with inflow..... from GLM and Lakes #2 & #1)	
5.3	Historical water use.....	
5.4.a	Lake survey plot of GLM-A2.....	
5.4.b	Lake survey plot of City Lake #1.....	
5.4.c	Lake survey plot of City Lake #2.....	
5.4.d	Lake survey plot of City Lake #3.....	
<u>6. Concordia</u>		
6.1.a	Storage Volume vs. Elevation (water supply lake).....	
6.1.b	Surface Area vs. Elevation (water supply lake).....	
6.2	RESOP run results (normal and optimum).....	
6.3	Historical Water Use.....	
6.4	Lake survey plot.....	

7. Creighton

7.1.a	Storage Volume vs. Elevation (water supply lake).....
7.1.b	Surface Area vs. Elevation (water supply lake).....
7.2	RESOP run results (normal and optimum).....
7.4	Lake survey plot.....

8. Dearborn

8.1.a	Storage Volume vs. Elevation (water supply lake).....
8.1.b	Surface Area vs. Elevation (water supply lake).....
8.2.a	RESOP run results (without pumping, normal and optimum).....
8.2.b	RESOP run results (with pumping, normal and optimum).....
8.3	Historical Water Use.....
8.4	Lake survey plot.....

9. Drexel

9.1.a	Storage Volume vs. Elevation (water supply lake).....
9.1.b	Surface Area vs. Elevation (water supply lake).....
9.2	RESOP run results (normal and optimum).....
9.4	Lake survey plot.....

10. Garden City

10.1.a	Storage Volume vs. Elevation (new water supply lake).....
10.1.b	Surface Area vs. Elevation (new water supply lake).....
10.1.c	Storage Volume vs. Elevation (old water supply lake).....
10.1.d	Surface Area vs. Elevation (old water supply lake).....
10.2.a	RESOP run results (new lake, normal and optimum).....
10.2.b	RESOP run results (old lake, normal and optimum).....
10.3	Historical Water Use.....
10.4.a	Lake survey plot new lake.....
10.4.b	Lake survey plot old lake.....

11. Green City

11.1.a	Storage Volume vs. Elevation (water supply lake).....
11.1.b	Surface Area vs. Elevation (water supply lake).....
11.2.a	RESOP run results (normal and optimum).....
11.2.b	RESOP run results (normal and optimum).....
11.2.c	RESOP run results (normal and optimum).....
11.2.d	RESOP run results (normal and optimum).....
11.3	Historical Water Use.....
11.4	Lake survey plot.....

12. Hamilton

12.1.a	Storage Volume vs. Elevation (water supply lake).....
12.1.b	Surface Area vs. Elevation (water supply lake).....
12.2	RESOP run results (Without pumping, with Pumping & Optimized).....
12.3	Historical Water Use.....
12.4	Lake survey plot.....

13. Harrison County Rural Water Dist. #1

13.1.a	Storage Volume vs. Elevation (water supply lake).....
13.1.b	Surface Area vs. Elevation (water supply lake).....
13.2.a	RESOP run results (lake only normal and optimum).....
13.2.b	RESOP run results (with basin normal and optimum).....
13.3	Historical Water Use.....
13.4	Lake survey plot.....

14. Higginsville

14.1.a	Storage Volume vs. Elevation (water supply lake).....
14.1.b	Surface Area vs. Elevation (water supply lake).....
14.1.c	Storage Volume and surface Area (sediment control pond).....
14.2.a	RESOP run results (normal and optimum without pumping).....
14.2.b	RESOP run results (normal and optimum with pumping).....
14.3	Historical Water Use.....
14.4	Lake survey plot.....

15. Holden

15.1.a	Storage Volume vs. Elevation (water supply lake).....
15.1.b	Surface Area vs. Elevation (water supply lake).....
15.2	Year vs. remaining storage (normal and optimum).....
15.4	Lake survey plot.....

16. James Port

16.1.a	Storage Volume vs. Elevation (water supply lake).....
16.1.b	Surface area vs. Elevation (water supply lake).....
16.2	RESOP run results (normal and optimum).....
16.4	Lake survey plot.....

17. King City

17.1.a	Storage Volume vs. Elevation (water supply south lake).....
17.1.b	Surface Area vs. Elevation (water supply south lake).....
17.1.c	Storage Volume vs. Elevation (lower North Lake #1).....
17.1.d	Surface Area vs. Elevation (lower North Lake #1).....
17.1.e	Storage Volume vs. Elevation (middle north lake #2).....
17.1.f	Surface Area vs. Elevation (middle north lake #2).....
17.1.g	Storage Volume vs. Elevation (upper north lake #3).....
17.1.h	Surface Area vs. Elevation (upper north lake #3).....
17.2.a	RESOP run results (south lake normal and optimum).....
17.2.b	RESOP run results (lower lake normal and optimum).....
17.2.c	RESOP run results (middle lake normal and optimum).....
17.2.d	RESOP run results (upper lake normal and optimum).....
17.3	Historical Water Use.....
17.4.a	Lake survey plot of south lake.....

18. Lamar

18.1.a	Storage Volume vs. Elevation (water supply lake).....
18.1.b	Surface Area vs. Elevation (water supply lake).....
18.2	RESOP run results (normal and optimum).....
18.3	Historical Water Use.....
18.4	Lake survey plot.....

19. Marceline

19.1.a	Storage Volume vs. Elevation (water supply lake).....
19.1.b	Surface Area vs. Elevation (water supply lake).....
19.1.c	Storage Volume vs. Elevation (old lake not surveyed).....
19.1.d	Surface Area vs. Elevation (old lake not surveyed).....
19.2.a	RESOP run results (normal and optimum Runs).....
19.2.b	RESOP run results (optimum Run).....
19.3	Historical Water Use.....
19.4	Lake survey plot.....

20. Memphis

20.1.a	Storage Volume vs. Elevation (Lake Show Me).....
20.1.b	Surface Area vs. Elevation (Lake Show Me).....
20.1.c	Storage Volume vs. Elevation (old lake).....
20.1.d	Surface Area vs. Elevation (old lake).....
20.2.a	RESOP run results (new lake normal and optimum runs).....
20.2.b	RESOP run results (old lakes) optimum Run only.....
20.3	Historical Water Use.....
20.4.a	New Lake survey plot.....
20.4.b	Old Lake survey plot.....

21. Middle Fork Grand River

21.1.a	Storage Volume vs. Elevation.....
21.1.a	Surface Area vs. Elevation.....
21.2	RESOP run results (normal and optimum).....
21.3	Historical Water Use.....
21.4	Lake survey plot.....

22. Milan

22.1.a	Storage Volume vs. Elevation (Elmwood Lake).....
22.1.b	Surface Area vs. Elevation (Elmwood Lake).....
22.1.c	Storage Volume vs. Elevation (Golf Course Lake).....
22.1.d	Surface Area vs. Elevation (Golf Course Lake).....
22.1.e	Storage Volume vs. Elevation....(Lake Shatto).....
22.1.f	Lake Surface Area vs. elevation...(Lake Shatto).....
22.2.a	RESOP run results, no pumping (Elmwood Lake, normal and optimum).....
22.2.b	RESOP run results with pumping (Elmwood Lake, normal and optimum).....
22.2.c	RESOP run results (Golf Course Lake normal and optimum).....
22.2.d	RESOP run results for Lake Shatto (optimum run).....
22.3	Historical Water Use.....
22.4.a	Elmwood Lake survey plot.....
22.4.b	Golf Course Lake Plot.....
22.4.c	Lake survey plot....(Lake Shatto).....

23. Moberly

23.1.a	Storage Volume vs. Elevation (Sugar Creek Lake).....
23.1.b	Surface Area vs. Elevation (Sugar Creek Lake).....
23.2	RESOP run results (normal, optimized, and..... optimized with input to lake from other source)
23.3	Historical Water Use.....
23.4	Lake survey plot.....

24. Monroe City RTE "J"

24.1.a	Storage Volume vs. Elevation.....
24.1.b	Surface Area vs. Elevation.....
24.2	RESOP run results (normal and optimum).....
24.3	Historical Water Use.....
24.4	Lake survey plot.....

25. Ridgeway

25.1.a	Storage Volume vs. Elevation.....
25.1.b	Surface Area vs. Elevation.....
25.2	RESOP run results (normal and optimum).....
25.3	Historical Water Use.....
25.4	Lake survey plot.....

26. Sedalia

26.1.a	Storage Volume vs. Elevation.....
26.1.b	Surface Area vs. Elevation.....
26.2	RESOP run results (normal and optimum).....
26.3	Historical Water Use.....
26.4	Lake survey plot.....

Figure:	Description	Page
----------------	--------------------	-------------

27. Shelbina

27.1.a	Storage Volume vs. Elevation.....	
27.1.b	Surface Area vs. Elevation.....	
27.2.a	RESOP run results (without Pumping From Salt River).....	
27.2.b	RESOP run results (with pumping from Salt River).....	
27.3	Historical Water Use.....	
27.4	Lake survey plot.....	

28. Unionville

Lake Mahoney and Lake Thunderhead Association

28.1.a	Storage Volume vs. Elevation (Lake Mahoney).....	
28.1.b	Surface Area vs. Elevation..(Lake Mahoney).....	
28.1.c	Storage Volume vs. Elevation (Lake Thunderhead).....	
28.1.d	Surface Area vs. Elevation (Lake Thunderhead).....	
28.2.a	RESOP run results (normal and optimum).(Lake Mahoney).....	
28.2.b	RESOP run results --(acre feet of storage)...(Lake Thunderhead).....	
	1. Both lakes optimized,	
	2. Unionville demand all from Lake Thunderhead	
	3. Optimize demand from Lake Mahoney and none from Lake Thunderhead	
28.2.c	RESOP run results --(Acre Feet of Storage)..(Lake Thunderhead).....	
	Optimum Demand – (Lake Mahoney and Lake Thunderhead)	
28.2.d	RESOP run results (acre feet of storage)...(Lake Thunderhead).....	
	1. Optimum demand from Lake Mahoney and none from Lake Thunderhead	
	2. Lake Mahoney optimized and rest of Unionville demand from Thunderhead	
	3. Unionville demand all from Lake Thunderhead. Used to compare.	
	(Figure 18.2.b item number 2 is a repeat of figure 18.2.c number 3)	
28.2.e	RESOP run results --(water surface elevation in Lake Thunderhead).....	
	1. Optimum from Lake Mahoney and none from Lake Thunderhead	
	2. Lake Mahoney optimized and rest of Unionville demand from Thunderhead	
	3. Unionville Demand all from Thunderhead	
28.2.f	RESOP run results (water surface elevation) both lakes optimized.....	
28.3	Historical Water Use.....	
28.4.a	Lake survey plot.(Lake Mahoney).....	
28.4.b	Lake survey plot..(Lake Thunderhead).....	

Streams and River Analysis Figures

40. Joplin: Shoal Creek

40.1	Joplin Missouri rainfall.....	
40.2.a	Shoal Creek annual runoff.....	
40.2.b	Shoal Creek annual runoff in mean cubic feet per second.....	
40.3.a	Compare probability of non-exceedence to 1953.....	
40.3.b	Compare probability of non-exceedence to 1954.....	
40.3.c	Compare probability of non-exceedence to 1955.....	
40.3.d	Compare probability of non-exceedence to 1956.....	
40.4.a	Base flow index.....	
40.4.b	Base flow runoff in inches.....	
40.4.c	Base flow runoff in cubic feet per second.....	
40.5	Probability plot for 7day Q10 low flow.....	
40.6	7-day annual low flow 1942 to 2000.....	
40.7	1%, 2% and 4% chance non-excedence flow.....	
40.8.a	1% chance flow and deficit.....	
40.8.b	2% chance flow and deficit.....	
40.8.c	4% chance flow and deficit.....	
40.8.d	Deficit in acre feet	
40.8.e	Deficit in mean cubic feet per second.....	
40.9	Annual withdrawal from Shoal Creek.....	
40.10.a	Mean 7-day low flow by months for 1953.....	
40.10.b	Mean 7-day low flow by months for 1954.....	

40.10.c	Mean 7-day low flow by months for 1955.....	.....
40.10.d	Mean 7-day low flow by months for 1956.....	.....

Figure:	Description	Page
----------------	--------------------	-------------

50. Perryville: Saline Creek

50.1	Perryville, Missouri rainfall.....	.....
50.2.a	Saline Creek annual runoff inches.....	.....
50.2.b	Saline Creek annual runoff in mean cubic feet per second.....	.....
50.3.a	Compare probability of non-exceedence to 1952.....	.....
50.3.b	Compare probability of non-exceedence to 1953.....	.....
50.3.c	Compare probability of non-exceedence to 1954.....	.....
50.3.d	Compare probability of non-exceedence to 1955.....	.....
50.3.e	Compare probability of non-exceedence to 1956.....	.....
50.3.f	Compare probability of non-exceedence to 1957.....	.....
50.4.a	Base flow index.....	.....
50.4.b	Base flow runoff in watershed inches.....	.....
50.4.c	Base flow runoff in mean annual cubic feet per second.....	.....
50.4.d	Compare St. Francis River flow data at Patterson and Fredericktown.....	.....
50.4.e	Compare St. Francis River flow data with Black River at Annapolis.....	.....
50.5	Probability plot for 7-day Q-10 low flow.....	.....
50.6	7-day annual low flow for 1950 to 2000.....	.....
50.7	1%, 2% and 4% chance non-excedent flow.....	.....
50.8.a	1% Chance mean monthly flow and deficit.....	.....
50.8.b	2% Chance mean monthly flow and deficit.....	.....
50.8.c	4% Chance mean monthly flow and deficit.....	.....
50.9	Water demand by Perryville.....	.....
50.10.a	Mean 7-day low flow by months for 1952.....	.....
50.10.b	Mean 7-day low flow by months for 1953.....	.....
50.10.c	Mean 7-day low flow by months for 1954.....	.....
50.10.d	Mean 7-day low flow by months for 1955.....	.....
50.10.e	Mean 7-day low flow by months for 1956.....	.....
50.10.f	Mean 7-day low flow by months for 1957.....	.....

60. Poplar Bluff: Black River

60.1	Poplar Bluff, rainfall.....	.....
60.2.a	Black River Annual runoff inch.....	.....
60.2.b	Black River Annual runoff in mean cubic feet per second.....	.....
60.3.a	Compare probability of non-exceedence to 1953.....	.....
60.3.b	Compare probability of non-exceedence to 1954.....	.....
60.3.c	Compare probability of non-exceedence to 1955.....	.....
60.3.d	Compare probability of non-exceedence to 1956.....	.....
60.4.a	Base flow Index adjusted for Clearwater Lake.....	.....
60.4.b	Base flow runoff in mean annual cubic feet per second below lake.....	.....
60.4.c	Total flow adjusted for release from lake in cubic feet per second.....	.....
60.4.d	Correlation of base flow two Black River gages.....	.....
60.4.e	Correlation of total flow for Clearwater Lake adjustment.....	.....
60.5.a	Probability plot for 7-day Q-10 low flow.....	.....
60.5.b	Correlation for 7-day Q-10 low flows for Black River gages.....	.....
60.6	7-day mean annual low flow 1940 to 2000.....	.....
60.7	1%, 2% and 4% chance non-excedent flow.....	.....
60.9	Water demand by Poplar Bluff.....	.....
60.10.a	Minimum 7-day low flow by months for 1953.....	.....
60.10.b	Minimum 7-day low flow by months for 1954.....	.....
60.10.c	Minimum 7-day low flow by months for 1955.....	.....
60.10.d	Minimum 7 day low flow by months for 1956.....	.....
60.11	Mean annual Storage in Clearwater Lake 1948 to 1992.....	.....

Figure:	Description	Page
---------	-------------	------

70. Trenton: Thompson River

70.1.a	Lamoni Iowa precipitation.....	
70.1.b	Princeton, Missouri precipitation.....	
70.2	Thompson River Annual Runoff.....	
70.3.a	Compare probability of non-excedence to 1954.....	
70.3.b	Compare probability of non-excedence to 1955.....	
70.3.c	Compare probability of non-excedence to 1956.....	
70.3.d	Compare probability of non-excedence to 1957.....	
70.4.a	Base flow index.....	
70.4.b	Base flow runoff in watershed inches.....	
70.4.c	Base flow runoff in mean monthly cubic feet per second.....	
70.5	Probability plot for 7day Q10 low flow.....	
70.6	7-day annual low flow 1930 to 2000.....	
70.7	1%, 2% and 4% chance non-excedence.....	
70.8.a	1% chance mean monthly flow and deficit.....	
70.8.b	2% chance mean monthly flow and deficit.....	
70.8.c	4% chance mean monthly flow and deficit.....	
70.8.d	Deficit in acre feet.....	
70.8.e	Deficit in mean cubic feet per second.....	
70.9.a	Historical Water use in million gallons per day.....	
70.9.b	Historical Water use in million gallons per year.....	
70.10.a	Mean 7-day low flow by months for 1954.....	
70.10.b	Mean 7-day low flow by months for 1955.....	
70.10.c	Mean 7-day low flow by months for 1956.....	
70.10.d	Mean 7-day low flow by months for 1957.....	

Water Supply Projections

Figure:	Description	Page
---------	-------------	------

Butler

80.1.a	Pump 33% of time from Marais Des Cygnes River into the lake during 1955 – 1957.....	
80.1.b	Pump 50% of time from Marais Des Cygnes River into the lake during 1955 – 1957.....	
80.1.c	Pump 33% of time from Marais Des Cygnes River into the lake during 1988 – 1990.....	
80.1.d	Pump 50% of time from Marais Des Cygnes River into the lake during 1988 – 1990.....	

Harrison County Water Dist #1 (Eagleville)

80.2.a	Water supply for 1955 – 1957 drought.....	
80.2.b	Water supply for 1988 – 1990 drought.....	

Hamilton

80.3.a	Water supply for 1955 – 1957 drought.....	
80.3.b	Water supply for 1988 – 1990 drought.....	

Marceline

80.4.a	Water supply for 1955 – 1957 drought.....	
80.4.b	Water supply for 1988 – 1990 drought.....	

Monroe City Rte “J” Lake

80.5.a	Water supply for 1955 – 1957 drought.....	
80.5.b	Water supply for 1988 – 1990 drought.....	

List of Tables

Table	Description	Page
-------	-------------	------

1	Summary of lake results.....	
2	Summary of stream and river studies.....	

INTRODUCTION

This report was prepared by Missouri Department of Natural Resources to address water supply needs and distribution as a result of extremely dry weather during the drought beginning in 1999 and extending into year 2004. Reservoirs were surveyed by USGS to determine the remaining storage of water for use by cities, communities, and rural water districts. This data is used for drought planning in establishing a network of available water supplies to be used to distribute to needed locations in North and West Central Missouri where water needs are met by surface sources. This report is not meant to be used as a regulatory manual.

Surface water supplies studied and contained in this report are:

Water Supply Systems

1. Adrian
2. Breckenridge
3. Butler
4. Brookfield
5. Cameron (4 lakes)
6. Concordia (E.A. Pape Lake)
7. Creighton
8. Dearborn
9. Drexel
10. Garden City (2 lakes)
11. Green City
12. Hamilton
13. Harrison County Rural Water District #1
14. Higginsville
15. Holden
16. James Port
17. King City (4 lakes)
18. Lamar
19. Middle Fork Grand River (Stanberry)
20. Milan (3 lakes) (Elmwood, Golf Course and Shatto Lakes)
21. Marceline
22. Memphis (Lake Show Me and Old City Lake)
23. Moberly
24. Monroe City RTE "J"
25. Ridgeway
26. Sedalia (Spring Fork Lake)
27. Shelbyna
28. Unionville (Lake Mahoney and Lake Thunderhead)

Also, this report contains Stream Flow analysis to selected cities obtaining their water supply from rivers and streams. These streams are:

1. Black River at Poplar Bluff
2. Saline Creek at Perryville
3. Shoal Creek at Joplin
4. Thompson River at Trenton

In addition, staff gages were installed in five lakes. The gages will aid in making estimates of remaining water supplies and projections during drought periods. These lakes are:

1. Butler
2. Eagleville, Harrison County Rural Water District #1
3. Hamilton
4. Marceline
5. Monroe City Rte. "J"

Additional lakes planned for study during year 2005 are:

- | | |
|------------------|------------------|
| 1. Kirksville | Forest Lake |
| 2. Kirksville | Hazel Creek Lake |
| 3. Bowling Green | City Lake #1 |
| 4. Bowling Green | City Lake #2 |
| 5. Vandalia | City Lake |

Lakes planned to be surveyed in 2005 and now delayed.

- | | |
|------------|----------------|
| 1. Fayette | DC Rogers Lake |
| 2. Fayette | Old City Lake |

ACKNOWLEDGEMENTS

Missouri Drinking Water Program staff members contributed to this project. They provided funding, direction and assistance to the study for communities having or expecting to have water shortage problems. Persons contributing were Jerry Lane, Don Scott, Everett Baker, and Bill Hills.

The United States Geological Survey staff located in Rolla, Missouri made field surveys of lakes.

EXECUTIVE SUMMARY

Missouri Department of Natural Resources Water Resources Program Surface Water Supply Staff has prepared an analysis of 34 communities water systems within Missouri. These include 30 lake systems and four systems using streams as their main water supply source. These systems are mostly in the north and western part of the state. Many of the cities and water supply districts in northern and western Missouri must obtain their supplies from surface water sources in areas where there is either a lack of available wells, poor water quality or both. Two of the southeastern streams studied are the exception. They are Black River at Poplar Bluff and Saline Creek at Perryville.

The objective of this water supply study is to provide technical hydrology and water resource engineering assistance to communities on how to allocate their water supplies during the critical drought of record in order to satisfy their needs during an extended multi-year dry episode. How we manage our water greatly effects the well being and economic stability of the area.

Scenario illustrations are presented for several communities to assist local decision-makers in allocating scarce water supplies. Projecting these scenarios upon current water demands through the most severe drought of record by placing optimum demands upon the reservoirs, streams, and off channel storage facilities in area will assist community leaders in determining if additional water supplies must be found or developed to advert water supply emergencies.

The 1950's drought is the most severe extended drought of record for Missouri. The time period 1951 through 1959, the "drought of record" was used as a base for determining the adequacy of present reservoir water supply capability.

Several of the examined water supply systems are from a collection of surface water sources, which can include several small lakes in series or tandem and often supplemented by in-stream diversion pumps. These analyses were made for some of the most critical supplies. Cities usually use two sources to supply their needs. These sources are lakes and flowing streams. Water stored in lakes comes from rainfall runoff to the lakes. Many of the lakes are too small in size and drainage area to satisfy local needs. As a result, the supply provided by the lakes must be supplemented by other sources. A common practice is to pump from streams into the lakes during high stream flows in an attempt to keep water levels in lakes near full. During droughts one can expect the streams to dry up or stream flow to be so low that pumping cannot be achieved. Basic engineering programs were used to study lake capacities and stream flows.

Staff gages are planned to be or have been installed on five of the lakes. By using these reservoir stage gages and with the analysis of historical droughts, supply projections can be made. We also produced frequency of depletion type charts. These charts can assist engineers to assess water needs and distribution. If an additional step is taken by the local communities to monitor supplies the local operators can project for themselves their remaining storage to empower public works directors on how to allocate existing water supplies.

Because of the gradual increases in demand for water, these charts will also assist in determining the urgency of providing new reservoirs and additional water storage facilities.

Tables one and two show the dependability of water supplies for each system. Not all systems could withstand a drought such as the one in the 1950's with their present demands.

MISSOURI WATER SUPPLY STUDIES

CITY	Lake Name	Drainage area		Annual Demand		Optimum Yield MGD from lake	Optimum Yield with pumping MGD	Year of Maximum Use	Lake Storage Acre-Ft	Comments
		Acres	Sq.Mi.	Gallons	MGD					
Adrian	City Lake	517	0.81	135,999,600	0.373	0.050	0.492	2000	290	
Breckenridge	City Lake	416	0.65	21,535,000	0.059	0.520	NA	2004	140	
Butler	City Lake	1990	3.11	366,878,000	1.010	0.270	1.010	2000	749	Lake & Marais Des Cygnes River
Brookfield	City Lake	650	1.02	620,000	0.620	0.207		2000		Lake only
	City Lake + stream			620,000	0.620		0.617			Lake plus stream
	City Lake			620,000	0.620		0.620			Lake, stream and holding basins
Cameron	GLM Lake	13382	20.91		1.000	1.000			1869	
	Cities 3 Lakes	3314	5.18						1382	3 Lake system
	Total	16696	26.09	556,000,000	1.500	1.500		2002	3251	Lakes in combination
Concordia	E.A. Pape Lake	5425	8.48	180,424,873	0.494	0.839	NA	2001	2740	
Creighton	City Lake	630	0.99	10,220,000	0.028	0.066	NA	2001	113	
Dearborn	City Lake	350	0.55	22,724,000	0.062	0.010	NA	1999	52	Dearborn now buys from K.C.
Drexel	City Lake #1	2989	4.67	0	0	0	NA			Not used for water supply
	City Lake #2	535	0.84	37,522,000	0.103	0.119	NA		345	Lakes not in series
	Total	3524	5.51	37,522,000	0.103	0.119	NA	2001		
Eagleville	Lake	3009	4.70	30,660,000	0.086	0.044	NA	2000	139.5	
	Basin	0	0.00			0.087				Storage basin added for volume
Garden City	Cities New Lake	430	1.70	29,889,810	0.082	0.182	NA	2000	441	
	Cities Old Lake	109	0.67	20,311,090	0.550	0.069	NA	2000	177	
	Total	539	2.37	50,200,900	0.632	0.251			618	
Green City	City Lake	800	1.25	66,612,500	0.183	0.149	NA	1999	428	
Hamilton	City Lake	1142	1.78	94,900,000	0.260	0.190	0.260	1999	896	Lake and Marrowbone Creek
Higginsville	City Upper Lake	1730	2.70	0	0.000	0	NA		128	For sediment control
	City Lower Lake	1700	2.66	348,980,000	0.956	0.462	1.310	2001	1462	Pump from Mo.River to lake
Holden	City Lake	2572	4.02	91,250,000	0.250	0.567	NA	2001	3810	
Jamesport	City Lake	900	1.41	21,900,000	0.060	0.069	NA	1999	163	
King City	South Lake	550	0.86		0.074	0.078		1999	417	
	North upper lake	60	0.09		0.005	0.005			39	
	North middle Lake	240	0.38		0.007	0.008			65	
	North lower lake	210	0.33		0.039	0.042			332	
	Total	1060	1.66	45,625,000	0.125	0.133	NA	1999	853	
Lake Thunderhead	Private Lake	14700	22.96	0	0.000	3.361	NA	NA	15,400	Not designed for water supply
Lamar	City Lake	3050	4.77	175,144,800	0.480	0.427	NA	2001	1582	Also use one well
	Well					0.430	NA			(2)600 GPM pumps
	Total					0.587	NA			Assume can pump 1/2 time
Marceline	Newer City Lake	2388	3.73	163,420,300	0.448	0.412	NA	2000	1990	
	Older City Lake	271	0.42	0	0.000	0.060	NA		est-462	Old Lake not used or surveyed
	Total	2659	4.15	163,420,300	0.448	0.472	NA	2000	2452	

Table 1

MISSOURI WATER SUPPLY STUDIES

CITY	Lake Name	Drainage area		Annual Demand		Optimum Yield MGD from lake	Optimum Yield with pumping MGD	Year of Maximum Use	Lake Storage Acre-Ft	Comments
		Acres	Sq.Mi.	Gallons	MGD					
Memphis	Lake Show Me	1700	2.66	153,300,000	0.420	0.780	NA	2000	4125	
	Old City Lake	965	1.51	0	0.000	0.095	NA		220	Downstream of New Lake
	Total	2665	4.17	153,300,000	0.420	0.875	NA	2000	4345	
Middle Fork	Lake	4037	6.30	127,750,000	0.350	0.381	NA	2000	915	Serves Stanberry
Milan	Elmwood Lake	4100	6.41	602,250,000	1.650	0.738	0.790	2000	2503	
	Golf Course Lake	680	1.06	0	0.000	0.116	0.116		555	
	Total	4780	7.47	602,250,000	1.650	0.854	0.906			Lake and Stream
Moberly	Sugar Creek Lake	7170	11.05	561,159,100	1.537	1.200	1.54	2001	5250	
Monroe City	Rt. J Lake	5250	8.20	152,701,000	0.418	1.010	NA	2001	1245	
Ridgeway		5723	8.94	13,991,000	0.038	0.246	NA	1999	461	
Sedalia	Spring Fork Lake	7030	10.98	990,657,900	1.535	1.059	NA	2001	1249	
Shatto	Lake near Milan	170	0.26			0.083	NA	NA	662	Not used for water supply
Shelbina	Lake	1542	2.41	127,249,000	0.349	0.273	0.380	1999	406	Pump from Salt River
Unionville	Lake Mahoney	1900.00	2.97	139,500,000	0.382	0.283	NA	2000	620	

Table 1

MISSOURI WATER SUPPLY STUDIES

Stream low flows

CITY	STREAM	Drainage Area Sq.Mi.	Annual Water use		7-day Q10		1 year In 50 *		1 year In 100		Year 2000	Comments
			Daily	Total	low flows		monthly flow		monthly flow		Flow	
			MGD	Gallons	cfs	MGD	cfs	MGD	cfs	MGD	cfs	
Joplin	Shoal Creek	427	10.82	3,949,175,941	43	28	46.0	30	38.0	25	226	No off channel storage
Perryville	Saline Creek	55.83	0.79	289,448,000	1	1	0.9	1	0.7	0.5	18	No off channel storage Use wells
Poplar Bluff	Black River	1245	3.08	1,122,486,000	216	140	254.0	164	222.5	144	603	No off channel storage
Trenton	Thompson	1670	1.90	694,520,000	9	6	7.5	5	4.6	3	55	Off Channel Storage

cfs is cubic feet per second

MGD is million gallons per day

* 1 year in 50 is the lowest mean monthly flow that is expected to occur one year out of 50 years.

Table 2

Introduction to Lake Analysis

These analyses were made for the drought of record, which was through the 1950's. At least two conditions are presented in all cases. The first run was made with current demand and the second was to optimize that demand to establish the firm yield. Other runs were made if necessary, such as effects of different schemes of pumping from a creek. If pumping from a stream was incurred, additional runs were made to evaluate effects of pumping.

USDA's Natural Resource Conservation Service reservoir operations computer program "RESOP" was used to make each evaluation. Computations are in one-month increments and represent end of month results. The "RESOP" program uses:

1. Lake volume and surface area
2. Rainfall
3. Runoff
4. Lake Evaporation
5. Seepage
6. Demand or water usage
7. Other inflow such as pumping from a stream.

Sources of data used to evaluate remaining storage in each reservoir are:

- Reservoir Storage - Reservoirs were surveyed for remaining available storage by the USGS from year 2000 to 2004.
- Time Period - The analysis for drought effects was selected to be the 1950's. This was the longest and most severe drought of record.
- Rainfall - Rainfall for each water supply lake was the nearest NOAA weather station. If there were missing days in the data, then the next nearest station was used to fill in the gaps.
- Runoff - Regional monthly runoff from nearest stream gages were used. If the Runoff did not look to be reasonable, i.e. Runoff greater than rainfall for a certain month, adjustments were made to the runoff by examining each individual rainfall event for that month. To make the runoff determination, five-day rainfall was used to estimate the antecedent moisture. The NRCS cover complex number was used to estimate runoff for each storm. See appendix "A" for an explanation.
- Evaporation - The nearest NOAA weather station with pan evaporation data was used. Pan evaporation was then adjusted to lake evaporation.
- Seepage - Seepage was estimated based on experience. In north Missouri seepage is very low.
- Demand - Demand is the amount of water available for consumptive uses. This value comes from community records.
- Other - Other is used to identify other inflow or outflow such as pumping from a stream.

"RESOP" is a DOS program. The users manual and software for the "RESOP" program are not included in this report but are available on CD upon request.

Missouri drinking water supplies studied and dates surveyed.

<u>Water Supply Lake</u>	<u>Date of Lake Bathymetry Survey</u>
1. Adrian.....	April 2003
2. Breckenridge.....	April 2004
3. Butler.....	April 2001
4. Brookfield.....	July 2000
5. Cameron .....Grindstone Reservoir....	Aug 1991
..... (3 City Lakes).....	June 1997
6. Concorde.....	June 2002
7. Creighton.....	June 2003
8. Dearborn.....	June 2000
9. Drexel.....	June 2003
10. Garden City.....(2 lakes).....	April 2004
11. Green City.....	July 2000
12. Hamilton.....	July 2000
13. Harrison County Rural Water Dist. #1.....	May 2003
14. Higginsville.....	June 2002
15. Holden.....	June 2003
16. James Port.....	July 2000
17. King City.....(4 lakes).....	July 2000
18. Lake Thunderhead Association	April 2003
19. Lamar.....	May 2002
20. Middle Fork Grand River Lake.....	July 2004
21. Milan.....(2 lakes).....	June 2000
22. Marceline.....	May 2003
23. Memphis.....(2 lakes).....	June 2001 & June 2002
24. Moberly.....	Dec. 2003
25. Monroe City RTE "J".....	June 2004
26. Ridgeway.....	May 2003
27. Sedalia.....	April 2002
28. Shatto Lake.....	July 2000
29. Shelbina.....	June 2001
30. Unionville.....	April 2004